

made to the following descriptions taken in connection with the accompanying drawings in which:

[0012] FIG. 1 depicts an example of a heterogeneous network in which some embodiments of the present invention may be practiced;

[0013] FIG. 2 depicts an example process for releasing dual connectivity in accordance with some example embodiments;

[0014] FIG. 3 illustrates a block diagram of a user equipment in accordance with some example embodiments; and

[0015] FIG. 4 illustrates a block diagram of a base station in accordance with some example embodiments.

DETAILED DESCRIPTION OF THE DRAWINGS

[0016] Dual connectivity refers to the scenario that a user equipment (UE) is connected simultaneously to two different base stations, for example, one macro cell base station which may also be called master base station or MeNB, and one small cell base station which may also be called secondary base station or SeNB. Master cell group (MCG) refers to a group of serving cells associated with MeNB. MCG includes at least a PCell, it may also have one or more SCells. Secondary cell group (SCG) refers to a group of serving cells associated with SeNB. SCG includes small cells, for example, a primary SCell which carries physical uplink control channel (PUCCH) information, it may also include one or more other SCells.

[0017] Controlling large number of small cells in SCG and UE mobility to the small cells or activation of the small cells can cause notable overhead to the system. Therefore it is desirable to have a mechanism that can reduce this overhead by giving more autonomy to UE while at the same time keeping the control of UE mobility, for example, PCell handover, at the network.

[0018] The subject matter disclosed herein provides a way for UE with dual connectivity to macro cell and small cell to release dual connectivity under certain conditions. Specifically, there is provided a way of configuring an inactivity timer and starting or restarting the timer when user data is active in at least one cell of SCG but not when user data is active in a cell of MCG—allowing the UE to release dual connectivity when the inactivity timer expires, which will save UE power because unused SCell connection is released, and if it so chooses, informing the macro cell about the releasing of dual connectivity.

[0019] It is noted that macro cell (or MeNB) and small cell (or SeNB) are used and will be hereinafter described for purposes of example, other cell sizes or types can be used as well according to the invention. It is also noted that LTE and WiFi are used and will be hereinafter described for purposes of example, other radio access technologies can be applied as well. Furthermore, it is noted that the invention could be applied at least in part to device to device (D2D) connection. For example, UE's connection to network is master and D2D connection is the secondary or vice-versa. Moreover, dual connectivity may also be between the same power class base stations/wifi spots, not just between a macro cell eNB and a small cell eNB.

[0020] FIG. 1 illustrates an example heterogeneous network 100 in which some example embodiments of the present invention may be practiced. As illustrated in FIG. 1, in the heterogeneous network 100, a UE 104 is in connection with a MeNB 101 and a SeNB 103. The UE 104 may have dual connectivity, where the UE consumes radio resources

provided by at least two different network points (MeNB 101 and SeNB 103) connected, for example, with non-ideal backhaul. The coverage areas of the eNBs are depicted by ellipses of different sizes, wherein the coverage area of the MeNB 101 is much larger than that of the SeNB 103 and overlays the coverage area of the SeNB 103. Within the same coverage area of the MeNB 101, UE's movement among small cells may lead to handover or reselection among small cells. The MeNB may be in connection with core network 102, for example, mobility management entity (MME) and serving gateway (S-GW), via S1 interface. In some example embodiments, the SeNB may be connected to the core network via MeNB. In some other example embodiments, the small cell eNB may be directly in connection with core network 102.

[0021] When bearer splitting is supported, a network may be more flexible regarding in which cell the network schedules the UE, but the macro-cell connection may still act as a backup if the small-cell connection fails for some reason. Bearer splitting means that a bearer, for example, an EPS bearer, can be routed via more than one eNB, for example, MeNB and SeNB in dual connectivity. Reference can be made to 3GPP TS 36.842 V12.0.0 (2013-12) 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Study on Small Cell enhancements for E-UTRA and E-UTRAN; Higher layer aspects (Release 12). This is similar to LTE Rel 10/11 carrier aggregation where one bearer can be scheduled via multiple cells. Reference can be made to 3GPP TS 36.211 V10.7.0 (2013-02) 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 10). In carrier aggregation, however, the two or more cells are served by the same eNB whereas in dual connectivity at least some of the cells are served by another eNB. Therefore, the macro cell layer may offer similar mobility robustness regardless of the type of cell that the UE is using to exchange data.

[0022] When bearer switch is supported, a bearer, for example, an EPS bearer, may be routed via only one eNB, for example, MeNB or a SeNB.

[0023] In some example embodiments, UE 104 may be implemented as a mobile device and/or a stationary device. The UE may be referred to as, for example, a wireless device, a mobile station, a mobile unit, a subscriber station, a wireless terminal, a tablet, a smart phone, a smart watch, and/or the like. In some example embodiments, UE 104 may be implemented as multi-mode user devices configured to operate using a plurality of radio access technologies, although a single-mode device may be used as well. For example, UE 104 may be configured to operate using a plurality of radio access technologies including one or more of the following: Long Term Evolution (LTE), wireless local area network (WLAN) technology, such as 802.11 WiFi and the like, Bluetooth, Bluetooth low energy (BT-LE), near field communications (NFC), and any other radio access technologies. The UE may be located within the coverage area of a cell or multiple cells.

[0024] Although FIG. 1 depicts a certain quantity and configuration of devices, other quantities and configurations may be implemented as well. For example, other quantities and configurations of base stations/access points, cells, and user equipment may be implemented as well.